CLINICAL LINGUISTICS & PHONETICS, 1992, VOL. 6, NO. 3, 191–200

Teaching and learning /θ/: a non-confound

JUDITH A. GIERUT and HEIDI J. NEUMANN

Department of Speech and Hearing Sciences, Indiana University, Bloomington, IN 47405, USA

(*Received 8 April 1991; accepted 9 August 1991*)

Abstract

The purpose of this study was to replicate and extend the findings on the effectiveness of homonymous versus non-homonymous treatment approaches for children with phonological disorders, following Gierut (1991b). The present study was motivated by a potential confound noted in the previous report; namely, the specific sounds /θ, ð/ treated in the presumably *less* effective homonymous condition may have inhibited degree of phonological change. It was thus necessary to teach these more difficult, late-acquired interdental fricatives in the *more* effective non-homonymous treatment condition using identical methods and procedures. Results indicated that a non-homonymous teaching approach again motivated greater phonological change than a homonymous approach, regardless of sounds that were taught. These findings have implications for the independence of linguistic structures of treatment in inducing sound change, and bear upon assumptions about ease of sound learning based on normative developmental sequences.

Keywords: Sound change, homonymy, child speech, phonological disorder.

A series of experimental clinical studies have been completed recently to evaluate the role of linguistic structure of treatment in inducing sound change in disordered phonological systems (Gierut, 1989, 1990, 1991a,b). In one study, Gierut (1991b) examined two different minimal pair contrast treatment approaches. One approach presented as input sound pairs that were realized homonymously by the child; the alternative approach presented non-homonymous sound pairs. More specifically, homonymous pairs were structured such that a target sound excluded from the child's grammar was taught in comparison to its 1 : 1 corresponding error replacement (given a relational comparison). This structure was consistent with conventional minimal pair treatment (Weiner, 1981). Non-homonymous pairs were structured such that two target sounds excluded from the child's grammar were compared in treatment. All children in this study received treatment on both homonymous and non-homonymous sound pairs within an alternating-treatments multiple-baseline-across-subjects design (ATD; Barlow and Hayes, 1979; Brady and Smouse, 1978; Kazdin and Hartmann, 1978; see also Ellis Weismer and Murray-Branch, 1989; Gierut, 1990, 1991a,b; Thompson and McReynolds, 1986; Ward and Bankson, 1989 for applications of this design to communication disorders). The relative and differential effect of treatment on both treated and untreated sounds was evaluated. Results indicated that, for all children, a non-homonymous treatment structure ensured greater phonological change than did a homonymous structure. Gierut

0269-9206/92 $3.00

concluded that such clinical treatment might provide the child with new and different phonological information, and that direct comparisons with the child's existing sound system may not be a necessary or sufficient condition of phonological change.

These results seem to have broad clinical implications; however, they were not unequivocal. In particular, the specific treated sounds may have biased the results. That is, all subjects received treatment on an interdental fricative /θ/ or /ð/ in the presumably *less* effective homonymous treatment condition, as summarized in Table 1. Interdental fricatives were never treated within the more effective non-homonymous minimal pair structure. This poses a potential confound if two assumptions are first accepted. In particular, it must be accepted that children learn sounds as unanalysable and independent units during contrast treatment. With this assumption, it is the sounds themselves, and not the distinctions among sounds, that are taken to be the treatment targets. This assumption is contrary to the expressed intent of contrast treatment, namely, to teach ambient feature distinctions among sounds and not specific sounds *per se* (Compton, 1970; Costello and Onstine, 1976; Dinnsen, Chin, Elbert and Powell, 1990; McReynolds and Bennett, 1972; Winitz, 1975). A second and related assumption is that certain sounds may be more difficult to produce or to learn, as based on reported sequences of acquisition. Consequently, teaching more difficult sounds may influence children's learning in negative or inhibitory ways. Given that interdental fricatives are generally said to be later acquired (Smit, Hand, Freilinger, Bernthal and Bird, 1990), the original results may have been artifactual because these sounds were always and only taught in the less effective homonymous treatment condition.

The present study was designed to address this possible confound of treated sound and treatment structure directly and, in turn, to potentially replicate and extend the initially reported treatment effects. In order to tease apart the confound of the previous study it became necessary to teach the presumably more difficult, late-acquired interdental fricative in the more effective non-homonymous minimal pair treatment condition. Predictably, if the linguistic structure of treatment is independent of the specific sounds that are taught, the non-homonymous teaching approach will again be shown to motivate greater change than the homonymous approach. Teaching an interdental fricative (versus teaching any other sound) will not influence degree of learning under these two treatment structures.

Table 1. *Summary of phonological change observed in homonymous (H) versus non-homonymous (N) treatment conditions as reported by Gierut (1991b) and herein.*

		Sound pairs and feature distinctions				Relative sound change		
	Subject	Homonymous vs. treatment conditions		Non-homonymous treatment conditions		Treated	Untreated	NSWs
Gierut	6	ð : d	[continuant]	dʒ : tʃ	[voice]	N ≥ H	N ≥ H	—
	8	θ : f	[coronal] [strident]	dʒ : z	[anterior] [continuant]	N ≥ H	N ≥ H	—
	9	ð : d	[continuant]	ʃ : s	[anterior]	N ≥ H	N ≥ H	—
This paper	20	s : t	[continuant] [strident]	ʃ : θ	[anterior] [strident]	N ≥ H	N ≥ H	N ≥ H

Subject

One phonologically disordered girl, age 4 years 8 months, was the subject of this study. The child had normal hearing and normal oral and speech motor abilities as determined by a standard audiometric screening (ASHA, 1985) and performance on the protocol developed by Robbins and Klee (1987), respectively. The child's receptive and expressive language were age-appropriate, as measured on the *Peabody Picture Vocabulary Test—Revised* (Form L, Dunn and Dunn, 1981) and the *Test of Early Language Development* (Hresko, Reid and Hammill, 1981). Also, she had normal intelligence as indicated by performance on the *Leiter International Performance Scale* (Arthur adaptation, Levine, 1986).

To determine subject eligibility, the *Goldman–Fristoe Test of Articulation* (Goldman and Fristoe, 1986) was first administered. The child met the minimum criterion of six sounds in error from two different sound classes and also ranked below the −1 percentile of age-based normative data for this measure. A generative description of the child's pretreatment phonological system was then developed based upon a sample of spontaneous connected speech and spontaneously elicited responses to the 198-item phonological knowledge protocol (PKP; Gierut, 1985). In this and in other studies of this series, our focus was only on sounds described by inventory constraints as determined by the standard generative analysis. Qualitatively, these were sounds never produced or used (correctly or incorrectly) in any word positions or in any morphemes; quantitatively, these sounds occurred with 0% accuracy in non-imitative contexts. Eight sounds were described by inventory constraints for this child: /θ, ð, s, z, ʃ, tʃ, dʒ, r/.

Experimental treatment procedures

Experimental design and treatment procedures were identical to those reported previously by Gierut (1990, 1991a,b), with two important exceptions. First, the clinician (H.N.) administering treatment and probes was blind to the experimental question and purpose of this study and, further, had no previous knowledge of or experience in applying the ATD. As a result, the potential for experimenter bias associated with treatment conditions was eliminated (see also interjudge transcription reliability reported below). Second, only one subject participated in this study, and thus the multiple-baseline-across-subjects design used previously was not applicable.

Briefly, then, the child was exposed to two treatment structures within an ATD in the remediation of two independent sound pairs. One sound pair was associated with homonymous treatment and consisted of the sound /s/ excluded from the child's pretreatment inventory and the comparison sound /t/ that was its 1 : 1 error replacement. The sound pair associated with the alternate non-homonymous treatment compared two sounds excluded from the child's pretreatment inventory. These were /θ/ and /ʃ/. Notice that /θ/ was targeted in the non-homonymous condition in order to directly address the potential confound mentioned above (Table 1). These specific sound pairs were also selected for treatment because they met criteria defined previously (Gierut, 1991b): both pairs differed by the same and fewest number of unique features and these never involved a major class distinction (i.e. [consonantal], [sonorant], [syllabic], following Chomsky and Halle, 1968). As before, both treatment conditions and hence both sound pairs were presented within each session. Order of treatment was randomly varied across sessions, such that a first approach was introduced, followed by a 10-min non-speech-related activity, and then a second approach was presented.

The effects of multiple treatment interference were controlled in ways identical to previous studies; namely, by counterbalancing order of treatment presentations, by presenting instructions to signal the switch in treatment conditions, and by obtaining baselines as explicit endpoints for comparisons of relative treatment effects. Consistent with the previous studies, differential responding associated with order of treatment presentation was not observed. Also, there were no observable additive effects of treatment, such that performance in one treatment condition enhanced performance in the other condition on a given day.

Treatment involved teaching targeted sounds in the initial position of nonsense words (NSWs), phonotactically permissible in standard English. The child was taught in imitative and spontaneous phases of production to predetermined performance criteria. Specifically, the child continued in the imitative phase until maintaining 75% accurate sound production over two consecutive sessions in at least one treatment condition. Treatment then shifted to the spontaneous phase and continued until the child maintained 90% accurate sound production over three consecutive sessions in at least one treatment condition.

Independent probes specific to each treatment were administered regularly, to evaluate relative changes in the phonological system. A probe was administered immediately following delivery of its associated treatment and averaged every other treatment session. Each probe sampled all eight sounds excluded from the child's pretreatment inventory, as spontaneously elicited in a picture-naming task. As described in Gierut (1990), probe items were selected from the PKP such that treated but excluded sounds, their voicing counterpart, and comparison sounds were each sampled in three prevocalic, one intervocalic, and three postvocalic exemplars. In addition, each remaining sound excluded from the child's inventory was sampled in one prevocalic and one postvocalic exemplar. Probe items were randomized for presentation and are listed in the appendix. Probe responses were audiorecorded and also phonetically transcribed on-line by one of the investigators (J.A.G.). Responses were judged correct if the sampled sound was produced as in the ambient language.

Interjudge transcription reliability was calculated on randomly selected probes. Twelve percent of the total number of probes administered were retranscribed by an independent judge (C.S.). A total of 137 consonants were retranscribed and compared point-to-point with the on-line transcriptions. Interjudge consonant agreement ranged from 88% to 93%, with a mean of 91%. Only one of the 137 consonants transcribed (i.e. 0·7%) involved relevant differences between the judges' transcriptions and their indication of whether these sounds were correct or incorrect relative to the adult target.

Results

Results of treatment were evaluated by considering relative changes in both treated and untreated sounds excluded from the child's pretreatment inventory. Criteria previously used to evaluate phonological change were again employed (Gierut, 1990, 1991a,b). Change in treated sounds was assessed with regard to the highest percentage of accuracy on any given probe (cf. Ellis Weismer and Murray-Branch, 1989), the percentage of accuracy on the final probes (cf. Winner and Elbert, 1988), and mean percentage of probe accuracy in each of the two treatment conditions. Data for treated sounds are shown in learning curves plotted in Figure 1.

Change in untreated sounds was determined by calculating mean percentages of accuracy for sounds excluded from the child's pretreatment inventory. Means were based on the total (and same) number of probes administered in each treatment condition. For each untreated sound, comparisons were made between the overall means associated with the homonymous versus the non-homonymous probes. A minimum 10% difference in mean probe scores was considered a relevant difference between treatment conditions for untreated sounds (cf. Elbert, Dinnsen and Powell, 1984; Gierut, 1990, 1991a,b).

Change as measured on probes

For treated sounds, criteria of highest and final percentages of accuracy were identical, as shown in Figure 1. Specifically, highest and final probe performance in the non-homonymous condition was 83% accuracy for /θ/ and 43% accuracy for /ʃ/. In the homonymous condition, highest and final probe accuracy was 57% for /s/. Mean probe accuracy was 33% for /θ/ and 27% for /ʃ/ in the non-homonymous condition, and 20% for /s/ in the homonymous condition.

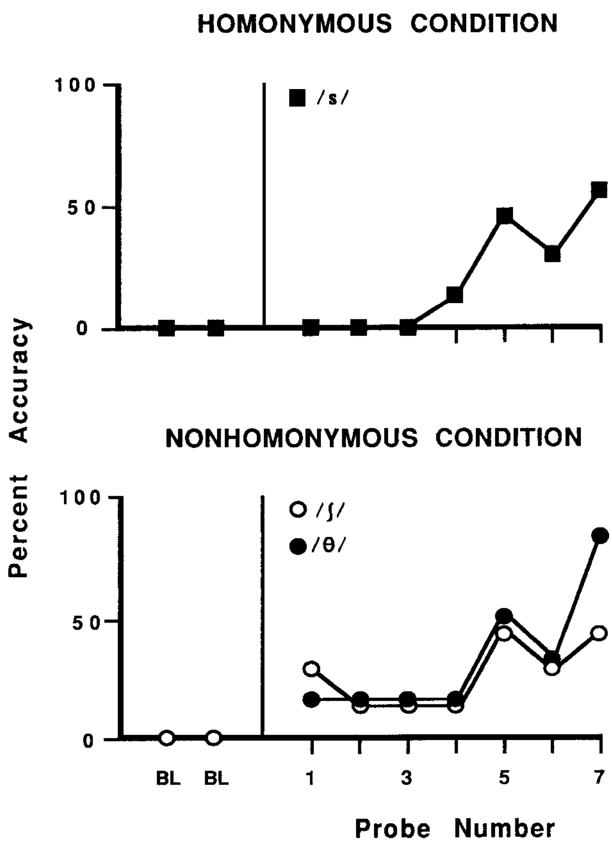

Figure 1. *Baseline and learning curves for treated sounds in each of the two treatment conditions as measured on probes.*

From these data, the greatest probe accuracy was observed in the non-homonymous treatment condition associated specifically with production of /θ/. It seems that treatment of an interdental fricative did not influence this child's learning in a negative or inhibitory way, as might have been projected (cf. Gierut, 1991b). Consistent with Gierut (1990, 1991b), the child's pattern of learning also was not predictable from a developmental sequence. Following normative data published by Smit and colleagues (Smit, Hand, Freilinger, Bernthal and Bird, 1990), it might have been expected that this child's performance on /ʃ/ would be better than that on /s/, which in turn would be better than that on /θ/. In fact, highest and final probe performance was just the reverse of that suggested by developmental norms: production of later-acquired sounds, /θ/ and /s/, was actually superior to that of a relatively earlier-acquired sound /ʃ/. Moreover, the specific nature of treated sounds did not seem to interact with treatment effectiveness. Regardless of the specific sounds being treated in this or the previous study, it was always the case that the non-homonymous teaching condition was as good as or better than the homonymous condition in inducing sound change.

For untreated sounds, mean difference scores indicated that only one new sound, the voiceless affricate, was added to the child's inventory in the non-homonymous condition; whereas, no new sounds were added in the alternative homonymous condition. This child evidenced greater (albeit limited) expansion of her inventory when two previously unknown sounds were taught in comparison to each other.

Despite the consistency of these findings with our previous research, this child's pattern of learning varied in a way that warrants further comment and evaluation. Specifically, changes induced in the more effective non-homonymous condition appeared to be associated with only one of the two treated sounds of the minimal pair; that is, /θ/ but not its comparison sound /ʃ/. In fact, accuracy of the sound treated in the *less* effective homonymous condition (i.e. /s/) often exceeded that of /ʃ/. Perhaps insight into the potential relationship among treated sounds can be gained from further evaluation of the child's performance during direct treatment of the NSWs. This metric has been cited as a possible means of evaluating treatment effectiveness and learning (Gierut, 1991b), but it has not yet been considered in studies of minimal pair paradigms. To establish unambiguously that the non-homonymous teaching approach motivated greater change in treated sounds for this child, an examination of this type now seems in order.

Change as measured during NSW treatment

Performance during treatment was evaluated by comparing the child's accuracy of responses to NSW stimuli during individual treatment sessions. Specifically, percentage of accuracy of each treated sound during each treatment session and mean percentage of accuracy of each treated sound over all sessions were considered. NSW treatment data are shown in the learning curves plotted in Figure 2. As shown in the figure, the child achieved greater accuracy in production of NSWs of the non-homonymous condition for the majority of treatment sessions. Specifically, for 10 of the 13 sessions, production of NSWs associated with *both* /θ/ and /ʃ/ was consistently better than production of those associated with /s/ in the homonymous condition. Only on sessions 6, 11, and 12 did accuracy of /s/ NSWs exceed accuracy of /θ/ or /ʃ/ NSWs. Mean treatment data over all sessions also support this general finding. Mean NSW accuracy was 78% and 77% for /θ/ and /ʃ/, respectively;

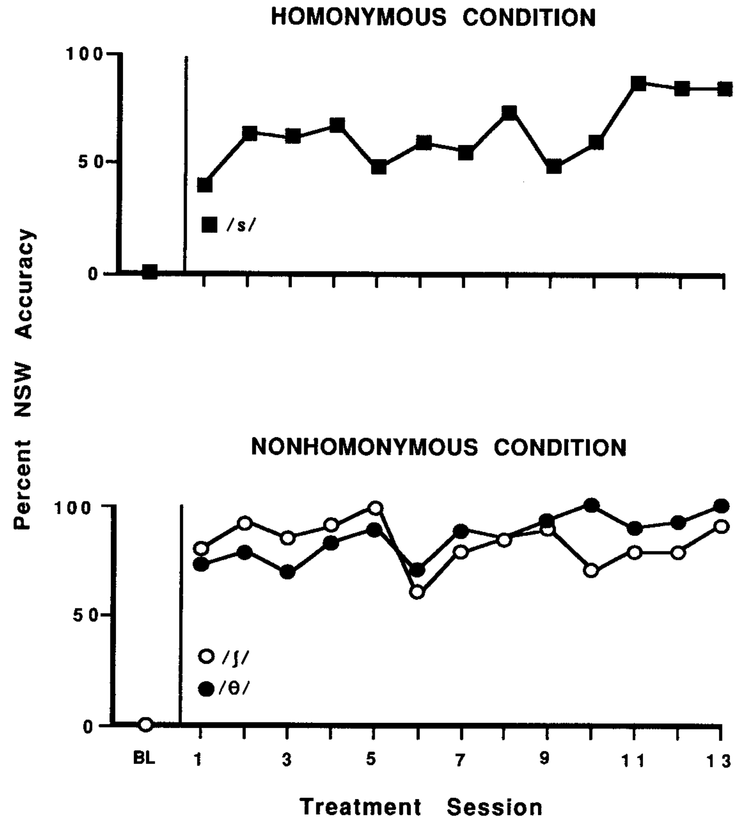

Figure 2. *Baseline and learning curves for production of treated sounds in NSWs as measured during direct treatment.*

whereas, mean accuracy for /s/ was 63%. It appears that, like probe performance, production of NSWs during treatment was also better for sounds treated in the non-homonymous condition than for that treated in the homonymous condition. Evaluation of treatment efficacy using direct treatment data further confirmed that this child's pattern of learning was, in fact, consistent with that of other subjects.

Conclusion

Both probe and treatment data demonstrated differential learning of sounds when using a non-homonymous versus homonymous treatment structure. In particular, when two target sounds excluded from the child's pretreatment phonology were compared to each other, performance was as good as or better than when one target sound was compared to its corresponding error replacement. That a non-homonymous approach to minimal pair teaching resulted in greater phonological gains was replicated and extended in this study. Importantly, the effectiveness of a non-homonymous treatment approach appears to be independent of the particular sound or sounds that may be taught.

The implication of this finding is that certain linguistic compositions may enhance phonological learning in treatment to greater or lesser degrees. It seems that the structure of phonological input, rather than the treated sounds *per se*, may be a more critical factor in inducing positive phonological change. A further implication is that sequences of sound acquisition, as outlined by normative data, may not be predictive of courses of clinically induced sound change. This observation is generally consistent with the literature on individual differences in phonological learning (Ferguson, 1977, 1989; Stoel-Gammon, 1985; Stoel-Gammon and Cooper, 1984; Vihman and Greenlee, 1987; Vihman, Ferguson and Elbert, 1986). This is not to say that certain aspects of phonology will not be more difficult to learn than others, but that ease or degree of phonological learning cannot be singularly determined on the basis of specific speech sounds. Rather, sound change appears to be motivated by the phonological distinctions that differentiate among sounds (Dinnsen *et al.*, 1990, Ingram, 1990) and the way in which these distinctions are structurally presented as input in treatment.

Acknowledgements

This research was supported in part by a grant from the National Institutes of Health (DC 00433) to Indiana University, and by an Honors Division Research Grant awarded by Indiana University to Heidi Neumann. We would like to thank Dan Dinnsen for comments on an earlier version of this manuscript, and Christina Simmerman for assistance with interjudge transcription reliability. Portions of this paper were presented at the 1990 American Speech-Language-Hearing Association Convention, Seattle. Address correspondence to Judith A. Gierut, Ph.D., Department of Speech and Hearing Sciences, Indiana University, Bloomington, IN 47405, USA.

Appendix: Probe words selected from the PKP

thunder	shirt	them
thief	shave	these
thumb	shovel	that
—	marshmallow	brother
tooth	push	—
bath	wash	—
mouth	brush	—
sun	tub	zebra
santa	tooth	zoo
soap	tear	zipping
baseball	potato	raisin
mouse	cut	nose
bus	bite	rose
ice	boot	noise
star	chalk	jeep
door	watch	orange

References

ASHA COMMITTEE ON AUDIOLOGIC EVALUATION (1985) Guidelines for identification audiometry. *Asha*, **27**, 49–52.

BARLOW, D. H. and HAYES, S. C. (1979) Alternating treatments design: one strategy for comparing the effects of two treatments in a single subject. *Journal of Applied Behavior Analysis*, **12,** 199–210.

BRADY, D. O. and SMOUSE, A. D. (1978) A simultaneous comparison of three methods for language training with an autistic child: an experimental single case analysis. *Journal of Autism and Childhood Schizophrenia*, **8,** 271–279.

CHOMSKY, N. and HALLE, M. (1968) *The Sound Pattern of English* (New York: Harper & Row).

COMPTON, A. (1970) Generative studies of children's phonological disorders. *Journal of Speech and Hearing Disorders*, **35,** 315–339.

COSTELLO, J. and ONSTINE, J. (1976) The modification of multiple articulation errors based on distinctive feature theory. *Journal of Speech and Hearing Disorders*, **41,** 199–215.

DINNSEN, D. A., CHIN, S. B., ELBERT, M. and POWELL, T. W. (1990) Some constraints on functionally disordered phonologies: phonetic inventories and phonotactics. *Journal of Speech and Hearing Research*, **33,** 28–37.

DUNN, L. M. and DUNN, L. M. (1981) *Peabody Picture Vocabulary Test-Revised* (Circle Pines, MN: American Guidance Service).

ELBERT, M., DINNSEN, D. A. and POWELL, T. W. (1984) On the prediction of phonologic generalization learning patterns. *Journal of Speech and Hearing Disorders*, **49,** 309–317.

ELLIS WEISMER, S. and MURRAY-BRANCH, J. (1989) Modeling versus modeling plus evoked production training: a comparison of two language intervention methods. *Journal of Speech and Hearing Disorders*, **54,** 269–281.

FERGUSON, C. A. (1977) New directions in phonological theory: language acquisition and universals research. In R. W. Cole (Ed.), *Current Issues in Linguistic Theory* (Bloomington, IN: Indiana University Press).

FERGUSON, C. A. (1989) Individual differences in language learning. In M. L. Rice and R. L. Schiefelbusch (Eds.), *The Teachability of Language* (Baltimore, MD: Paul H. Brookes).

GIERUT, J. A. (1985) *On the Relationship between Phonological Knowledge and Generalization Learning in Misarticulating Children* (Bloomington, IN: Indiana University Linguistics Club).

GIERUT, J. A. (1989) Maximal opposition approach to phonological treatment. *Journal of Speech and Hearing Disorders*, **54,** 9–19.

GIERUT, J. A. (1990) Differential learning of phonological oppositions. *Journal of Speech and Hearing Research*, **33,** 540–549.

GIERUT, J. A. (1991a) *The conditions and course of clinically-induced phonological change.* Manuscript submitted for publication.

GIERUT, J. A. (1991b) The role of homonymy in phonological change. *Clinical Linguistics and Phonetics*, **5,** 119–137.

GOLDMAN, R. and FRISTOE, M. (1986) *Goldman-Fristoe Test of Articulation* (Circle Pines, MN: American Guidance Service).

HRESKO, W. P., REID, D. K. and HAMMILL, D. D. (1981) *The Test of Early Language Development* (Austin, TX: Pro-ed).

INGRAM, D. (1990) Toward a theory of phonological acquisition. In J. Miller (Ed.), *Research on Child Language Disorders* (Boston, MA: College-Hill Press).

KAZDIN, A. E. and HARTMANN, D. P. (1978) The simultaneous-treatment design. *Behavior Therapy*, **9,** 912–922.

LEVINE, M. N. (1986) *Leiter International Performance Scale: A Handbook* (Chicago, IL: Stoelting).

MCREYNOLDS, L. V. and BENNETT, S. (1972) Distinctive feature generalization in articulation training. *Journal of Speech and Hearing Disorders*, **37,** 462–470.

ROBBINS, J. and KLEE, T. (1987) Clinical assessment of oropharyngeal motor development in young children. *Journal of Speech and Hearing Disorders*, **52,** 271–277.

SMIT, A. B., HAND, L., FREILINGER, J. J., BERNTHAL, J. E. and BIRD, A. (1990) The Iowa articulation norms project and its Nebraska replication. *Journal of Speech and Hearing Disorders*, **55,** 779–798.

STOEL-GAMMON, C. (1985) Phonetic inventories, 15–24 months: a longitudinal study. *Journal of Speech and Hearing Research*, **28,** 505–512.

STOEL-GAMMON, C. and COOPER, J. A. (1984) Patterns of early lexical and phonological development. *Journal of Child Language*, **11,** 247–271.

THOMPSON, C. K. and MCREYNOLDS, L. V. (1986) *Wh* interrogative production in agrammatic aphasia: an experimental analysis of auditory-visual stimulation and direct-production treatment. *Journal of Speech and Hearing Research*, **29,** 193–206.

VIHMAN, M. M. and GREENLEE, M. (1987) Individual differences in phonological development: ages one and three years. *Journal of Speech and Hearing Research*, **30,** 503–521.

VIHMAN, M. M., FERGUSON, C. A. and ELBERT, M. (1986) Phonological development from babbling to speech: common tendencies and individual differences. *Applied Psycholinguistics*, **7,** 3–40.

WARD, J. M. and BANKSON, N. W. (1989) *Phonological generalization associated with the traditional and minimal contrast approaches* (Paper presented at the American Speech-Language-Hearing Association Convention, St Louis, MO).

WEINER, F. F. (1981) Treatment of phonological disability using the method of meaningful minimal contrast: two case studies. *Journal of Speech and Hearing Disorders*, **46,** 97–103.

WINITZ, H. (1975) *From Syllable to Conversation* (Baltimore, MD: University Park Press).

WINNER, M. and ELBERT, M. (1988) Evaluating the treatment effect of repeated probes. *Journal of Speech and Hearing Disorders*, **53,** 211–218.